## Nemaha Basin

The Nemaha River Basin (Basin) in Nebraska is defined as the areas of Nebraska south of the Platte River Basin that drain directly into the Missouri River and includes the Missouri River below its confluence with the Platte River, Figure N-1. Major streams in the Basin include Weeping Water Creek, the Little Nemaha River, the Big Nemaha River, and the Missouri River, Figure N-2. The total area of the Basin is approximately 2,800 square miles and includes all of Johnson, Nemaha, Otoe, and Richardson counties and portions of Cass, Gage, Lancaster, and Pawnee counties. County seats in the Basin include Auburn, Falls City, Nebraska City, Pawnee City, Plattsmouth, and Tecumseh.

Streams in the Basin are incised into the glacial tills and loess that cover the entire Basin. Stream orientation is nearly perpendicular to the direction of the glacial advance with the majority of the streams flowing from the northwest to the southeast. The exception is the Big Nemaha River which is the furthest south major stream. Its headwaters are in Kansas, where it flows northeast across the Nebraska–Kansas state line, continues northeast a short distance then gradually changes direction to the southeast. All streams in the Basin discharge to the Missouri River.

### Sources of Water

#### *Precipitation*

Annual and growing season (May 1 through September 30) precipitation charts for gage sites in Auburn, Falls City, Nebraska City, and Tecumseh are presented in Figures N-3 through N-10. The average annual precipitation ranges from 29.1 inches at Lincoln near the northwestern end of the Basin to 34.7 inches at Falls City in the southeast corner of the Basin. The average growing season precipitation ranges from 19.2 inches at Lincoln to 22.1 inches at Falls City. Locations of the precipitation gages can be seen in Figure N-11.

*Ground Water*

The hydrogeology of the Basin is complex due to the glacial origin of the recent sediments. The entire Basin has been glaciated, Figure N-12. For purposes of this report, all saturated unconsolidated sediments of Quaternary age above bedrock inclusive of the paleovalley alluvial aquifers, the Missouri alluvial aquifers and the shallow aquifers are combined into the principal aquifer unit for the Basin. Secondary aquifers are the bedrock aquifers. Tables N-1 and N-2, which are from the Nemaha Natural Resources District (NRD) Ground Water Management Plan, list the aquifers by age with the important hydrogeologic characteristics. The bedrock aquifers range in age from Cretaceous to Pennsylvanian, Figure N-13. The bedrock aquifers supply a small amount of water compared to the other aquifers but are an important source locally (CSD, 2005). They generally are not in hydrologic connection with the streams in the Basin.

The principal aquifer varies in saturated thickness from 0 to approximately 500 feet, Figure N-14. Depth to water from the land surface varies from 0 to more than 200 feet, Figure N-15 (CSD 2005). Transmissivity values range from less than 20,000 gallons per day per foot (gal/day/ft) to more than 150,000 gal/day/ft. Most areas of the Basin have transmissivity values of less than 20,000 gal/day/ft, Figure N-16. Areas of higher transmissivity are generally related to the paleovalley and Missouri River alluvial aquifers. Specific yield ranges from less than 5 to greater than 20 percent, Figure N-17. Due to the glaciated nature of the area, the principal aquifer is not always in hydrologic connection with the streams, except the Missouri River alluvial aquifers (CSD 2005). The ground water table, Figure N-18, reflects the complicated nature of this glaciated area. Ground water tends to move from the uplands to the streams however the ground water contour map should not be taken as an expression of the hydrologic connection (CSD 2005).

*Ground Water Use*

Ground water in the Basin is used for a variety of purposes: domestic, industrial, livestock, irrigation, and others. There are 1,400 registered ground water wells within the Basin as of October 1, 2005 (Department registered ground water wells database). Not all wells are registered in the Department database, especially stock and domestic wells, which if drilled prior to 1993 are not required to be registered. Certain dewatering and other temporary wells are not required to be registered. Irrigation is the largest consumer of ground water, with approximately 46,000 acres being supplied with water from approximately 400 wells as of October 1, 2005 (Department registered ground water wells database).

Ground water development for irrigation is controlled by the geology of the area and the suitability of the land surface for irrigation. Figure N-19 illustrates the location of depletive ground water wells. Depletive wells are those wells that consume water and thus remove water from the ground water system. Depletive wells include uses for: aquaculture, commercial, domestic, irrigation, public water supply, dewatering, stock, and other, except those in the other category noted as sparge, vapor extraction, or another non-consumptive use.

Most wells are found in the alluvial valleys, paleovalleys and Missouri alluvial aquifers. Ground water development analyzed by comparison of completion dates has shown that development of high capacity wells (depletive wells capable of pumping more than 50 gallons per minute) has been steadily increasing with accelerated increases during the years 1964 through 1981 and 2001 to the present, Figures N-20, N-21, and N-22. Table N-3 shows the estimated average irrigated acreage by county within the Basin between 1950 and 2003. The increase in the number of other depletive wells seen in Figures N-21 and N-22 after 1993 is attributed to revision of the well registration statute in 1993.

*Changes in Ground Water Table Elevation*

Figure N-23 is a map made from a compilation of all ground water table elevations reported to the Conservation and Survey Division of the University of Nebraska-Lincoln in cooperation with the U.S. Geological Survey and the Natural Resources Districts. It shows a small area in northwest Nemaha County with small declines in ground water table elevations from predevelopment through the spring of 2005. Figure N-24 is the location map for selected ground water hydrographs across the Basin. Figures N-25 through N-27 are hydrographs (USGS 2005) which give a representative change in ground water table elevations for the particular area. Where possible a graph of a continuous recorder site is used.

*Ground Water Management*

The Basin primarily encompasses portions of two Natural Resources Districts (NRDs): the Nemaha NRD (NNRD) and the Lower Platte South NRD (LPSNRD).

The NNRD has established a ground water management area (GWMA) for quality purposes and the LPSNRD has established a GWMA for quality and quantity purposes. As part of the GWMA requirements in each of these districts, permits are required prior to the construction of wells pumping greater than 50 gallons per minute (gpm).

*Surface Water*

Hydrographs from four surface water gages in the Basin are included in this report, Figures N-28 through N-31. They are Weeping Water Creek at Union, Little Nemaha River at Auburn, Big Nemaha River at Falls City and the Missouri River at Rulo, Figure N-32. Streamflow in the Basin is primarily driven by precipitation and generally follows the annual variations in precipitation.

*Surface Water Use*

As of October 1, 2005, there are approximately 800 surface water appropriations in the Basin issued for a variety of uses. The majority of the surface water appropriations are for irrigation use and they tend to be located on the major streams. There are no instream flow appropriations in the Basin. The first surface water appropriations in the Basin were permitted in 1934 and development has continued through present day. The largest period of development occurred in the 1970's, Figure N-33 and Figure N-34. The approximate locations of the surface water irrigated acres are shown in Figure N-35. Information on specific surface water appropriations is available in the Department's biennial report. Information on categories of use can be found in Appendix H.

Analyses for the Fully Appropriated Determination

*Surface Water Administration*

In the 70-year period since the first surface water appropriation was perfected in the Basin, there have only been a few recorded instances of surface water administration in the administrative record, with the first occurring in 1977. A summary of water administration that occurred between 1985 and 2004 can be found in Table N-4. The junior surface water appropriations in the Basin had an average of 59 days in which surface water was available for diversion from July 1 through August 31 and 150 days in which surface water was available diversion from May 1 through September 30.

The senior surface water appropriations that caused administration in the Basin have priority date years prior to 1985 (1957 and 1974 are the known dates from the administration record); therefore it is not necessary to reconstruct the water administration table.

Table N-4. Water Administration in the Nemaha Basin between 1985 and 2004.

| Year | Water Body | Days | Closing Date | Opening Date |
|---|---|---|---|---|
| 1985 | Little Nemaha River | 2 | Jul 17 | Jul 19 |
| 1989 | Little Nemaha River | 25 | | |
| 1989 | North Fork Big Nemaha River | 14 | | |
| 1989 | Long Branch | 5 | | |
| 1990 | North Fork Little Nemaha River | 14 | July | July |
| 1991 | Little Nemaha River | 7 | Jul 2 | Jul 9 |
| 1991 | Little Nemaha River | 19 | Jul 18 | Aug 6 |
| 1991 | North Fork Little Nemaha River | 1 | Jul 8 | Jul 9 |
| 2002 | Weeping Water Creek | 21 | Jul 30 | Aug 20 |
| 2004 | Weeping Water Creek | 3 | Aug 23 | Aug 26 |

*Determination of Hydrologically Connected Area*

No sufficient numeric ground water model is available in the Nemaha Basin to determine the 10/50 area or the lag impact of ground water wells.

The Jenkins method can only be applied where sufficient data and appropriate hydrogeologic conditions exist. In most of the Basin the principal aquifer is absent or very thin due to the glaciated nature of the area (CSD 2005). Additionally, where there is a principal aquifer present, the complex hydrogeologic nature of this area makes the degree of connection between the ground water system and the surface water system poor and uncertain (CSD 2005). The area of the Basin with hydrologic connection to the streams is limited to a very slim area where the Missouri River aquifer exists.

There is no determination of the 10/50 area due to the hydrogeologic complexities of the Basin and lack of sufficient data. As better and more data become available it may be possible to determine areas of the principal aquifer that meet the criteria for determining the 10/50 area.

*Lag Impacts*

a) Current Well Development

Due to the lack of sufficient hydrogeologic data, no lag impacts were calculated for the Basin. The lack of lag calculation is a result of the same factors that limited the use of the Jenkins method as described in the subsection on "Determination of Hydrologically Connected Area."

Even if lag impacts could be calculated, other information suggests that current well development has a minimal impact on the long term streamflow. Many high capacity ground water wells have been completed in the Basin in the last 40 years, but there are no large areas of ground water decline or observed decreases in streamflow that are not mostly due to cyclical climatic conditions. Most high capacity wells have been developed in the principal aquifer, outside of the alluvial valleys.

b) Future Well Development

The lag impact calculation for projected future development was not carried out for the same reasons as stated above. Estimates of the number of high capacity wells that would be completed over the next 25 years if no new legal constraints were imposed were calculated based on extrapolating the present day rate of increase in well development into the future, Figure N-36. For the past 20 years, the rate of increase in high capacity wells is nearly linear at a rate of 9 wells per year.

*Future Surface Water Development and Uses*

The number of surface water appropriations in the Basin has grown steadily over the past 30 years and there is no reason to believe that that trend will not continue into the future, Figure N-33. The number of irrigated acres permitted for surface water irrigation also

has grown steadily for the past 30 years, Figure N-34, and no significant changes to that rate of growth are expected in the future.

*Ability to Satisfy Net Corn Crop Irrigation Requirement*

Figure N-37 shows the net corn crop irrigation requirement for the Basin. The map shows the net corn crop irrigation requirement to be less than 7.0 inches for the entire Basin. Assuming a surface water diversion rate equal to 1 cubic foot per second per 70 acres and a downtime value of 10 percent; depending on the location in the Basin, it takes approximately 18.6 days annually to divert 65% of the net corn crop irrigation requirement from July 1 through August 31 and approximately 24.3 days to divert 85% of the net corn crop irrigation requirement from May 1 through September 30.

The surface water administration analysis showed an average of at least 59 days in which surface water was available for diversion from July 1 through August 31 and an average of at least 150 days in which surface water was available for diversion from May 1 through September 30.

*Sufficiency of Surface Water Supply [Nebraska Revised Statutes Section 46-713(3)(a) (Reissue 2004)]*

The average number of days in which surface water was available for diversion in both the July 1 through August 31 and the May 1 through September 30 time frames required by Department rule 457 Nebraska Administrative Code (NAC) 24.001.01 exceeds the number of days surface water is required to be available pursuant to the rule during those same periods. Because the average annual number of days available in which surface water was available for diversion far exceed the number of days required (59 available versus 18.6 needed and 150 available versus 24.3 needed) it is unlikely that the existing level of well development will cause flows in any Nemaha Basin river or its tributaries to fall to the point where they may become fully appropriated without the initiation of additional uses. Table N-5 summarizes the results of comparisons between the number of

days surface water must be available to meet the 65% and 85% net corn crop irrigation requirements and the number of days in which surface water was available for diversion to the junior surface water appropriations.

Table N-5. Summary of Comparison Between Net Corn Crop Irrigation Requirement and Number of Days Surface Water is Available for Diversion.

| | Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement | Average Annual Number of Days Available to the Junior Surface Water Appropriations (1985-2004) | Average Annual Number of Days Available in 2030 with no Additional Well Development | Average Annual Number of Days Available in 2030 with Additional Well Development |
|---|---|---|---|---|
| July 1 – August 31 | 18.6 | 59 (40.4 days above the requirement) | Not Calculated* | Not Calculated* |
| May 1 – September 30 | 24.3 | 150 (125.7 days above the requirement) | Not Calculated* | Not Calculated* |

* This number was not calculated. Because the number of days in which surface water was available for diversion far exceed the number of days necessary to meet the net corn crop irrigation requirement, the final conclusion would not change even with the addition of lag impacts from additional wells.

*Sufficiency of Streamflow for Ground Water Supply [Nebraska Revised Statutes Section 46-713(3)(b) (Reissue 2004)]*

Since the criteria for Nebraska Revised Statutes Section 46-713(3)(a) were satisfied, the conclusion for this section is the same for reasons explained in the report introduction.

*Sufficiency of Surface Water Supply for Compliance with Compacts or State Laws [Nebraska Revised Statutes Section 46-713(3)(c) (Reissue 2004)]*

There are no compacts on any portions of the Nemaha Basin in Nebraska.

*Future Development of Surface and Ground Water [Nebraska Revised Statutes Section 42-713(1)(b) (Reissue 2004)]*

Given the rate of registered ground water well and surface water appropriation development, the conclusion that the Basin is not fully appropriated would not change even if no additional legal constraints were placed on development and a reasonable projection of a continuation of the current trend of well development of the last 20 years is used.

Conclusions

There is no evidence that current ground water depletions to streamflow in the Basin are affecting surface water users sufficiently to meet the criteria for being fully appropriated as found in Department rule 457 NAC 24.001.01 when compared to the amount of surface water available at the present time.

There is no evidence available at this time that lag impact will be sufficient in 25 years to affect existing water users enough to meet the criteria for being fully appropriated as found in Department rule 457 NAC 24.001.01.

Based upon available information and its evaluation, the Department has reached a determination that the Basin is not fully appropriated. The Department has also determined that even if no additional legal constraints are imposed on future development of hydrologically connected surface water and ground water and reasonable projections are made about the extent and location of future development, this conclusion would not change.